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Abstract

THE MANAGEMENT OF HEAVY WATER FOR RESEARCH AND POWER REACTORS

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1. Canada has had experience with several heavy-water reactor systems including one operating at high pressure and high temperature. All the systems are complex and the larger ones allow entry for changing fuel with the reactor at power. Inevitably some heavy water escapes and the systems have been designed to keep the quantities that escape to a minimum. Tritium is associated with any irradiated heavy water and the concentrations that arise when there is an escape call for measures to prevent hazards to personnel.

2. During the last six years the amount of H_2O entering the D_2O systems of the NRX and NRU reactors was less than 100 parts per million per year. The major problem was the reclamation of heavy water that escaped from the reactors, particularly when it was diluted with H_2O (i.e. downgraded) or contaminated with undesirable impurities. The amount of downgraded heavy water collected during routine reactor operation was not large (500 kg/year for the NRX reactor), but, in three instances, very large quantities (>10 000 kg) of heavy water were downgraded and in each instance the reclamation problems were different. The recovery of D_2O from ventilation systems is usually not economic, but a commercial unit with alumina has been effective in a ventilation system at the Nuclear Power Demonstration reactor (NPD). Most impurities, with the exception of organics, are removed successfully on ion-exchange resin. Oil can be brought down to about one part per million with filter-aids and then this trace removed with an ion-exchange resin.

3. Distillation and electrolysis have both been used for the isotopic reconcentration of water containing less than 99.75 wt% D_2O. Distillation is better where the full benefits of an automated system can be realized, i.e. for removing small quantities of H_2O from large volumes of D_2O and for reconcentrating large volumes of low-grade water (< 65 wt% D_2O).

The electrolytic process is more versatile and is particularly well suited to water containing over 90 wt% D_2O; its small batch size, as low as 50 kg for a single cell, is an advantage. The separation factor α, which is a measure of the efficiency of an electrolytic plant, usually exceeded nine and often exceeded ten.

4. The isotopic analysis of water containing less than 99 wt% D_2O is not accurate enough for precise accounting, especially when large volumes are involved.

5. The tritium concentration of the D_2O in the NRX and NRU reactors has been about 5 curies/liter for several years. From January to October, 1963, 295 persons were exposed to tritium; of these 87% received less than 0.5 rem and less than 1% exceeded 1 rem. All the operators in the electrolytic plant received less than 0.5 rem. Adequate ventilation, good housekeeping, properly designed equipment, and sound operating procedures are key factors in the control of this hazard.